Chest radiographs for acute lower respiratory tract infections

Cao, Amy Millicent; Choy, Joleen P.; Mohanakrishnan, Lakshmi Narayana; Bain, Roger F.; van Driel, Mieke L.

Published in:
Cochrane Database of Systematic Reviews

DOI:
10.1002/14651858.CD009119.pub2

Cochrane Library

Cochrane Database of Systematic Reviews

Chest radiographs for acute lower respiratory tract infections (Review)

Cao AMY, Choy JP, Mohanakrishnan LN, Bain RF, van Driel ML

Cao AMY, Choy JP, Mohanakrishnan LN, Bain RF, van Driel ML.
Chest radiographs for acute lower respiratory tract infections.
Cochrane Database of Systematic Reviews 2013, Issue 12. Art. No.: CD009119.
DOI: 10.1002/14651858.CD009119.pub2.

www.cochranelibrary.com

WILEY

TABLE OF CONTENTS

[Intervention Review]

Chest radiographs for acute lower respiratory tract infections

Amy Millicent Y Cao[1], Joleen P Choy[1], Lakshmi Narayana Mohanakrishnan[1], Roger F Bain[1], Mieke L van Driel[2,3,4]

[1]Faculty of Health Sciences and Medicine, Bond University, Gold Coast, Australia. [2]Discipline of General Practice, School of Medicine, The University of Queensland, Brisbane, Australia. [3]Centre for Research in Evidence-Based Practice, Bond University, Gold Coast, Australia. [4]Department of General Practice and Primary Health Care, Ghent University, Ghent, Belgium

Contact address: Lakshmi Narayana Mohanakrishnan, Faculty of Health Sciences and Medicine, Bond University, University Drive, Gold Coast, Queensland, 4229, Australia. motazz07@gmail.com.

Editorial group: Cochrane Acute Respiratory Infections Group.
Publication status and date: New, published in Issue 12, 2013.
Review content assessed as up-to-date: 5 February 2013.

Citation: Cao AMY, Choy JP, Mohanakrishnan LN, Bain RF, van Driel ML. Chest radiographs for acute lower respiratory tract infections. *Cochrane Database of Systematic Reviews* 2013, Issue 12. Art. No.: CD009119. DOI: 10.1002/14651858.CD009119.pub2.

ABSTRACT

Background

Acute lower respiratory tract infections (LRTIs) (e.g. pneumonia) are a major cause of morbidity and mortality and management focuses on early treatment. Chest radiographs (X-rays) are one of the commonly used strategies. Although radiological facilities are easily accessible in high-income countries, access can be limited in low-income countries. The efficacy of chest radiographs as a tool in the management of acute LRTIs has not been determined. Although chest radiographs are used for both diagnosis and management, our review focuses only on management.

Objectives

To assess the effectiveness of chest radiographs in addition to clinical judgement, compared to clinical judgement alone, in the management of acute LRTIs in children and adults.

Search methods

We searched CENTRAL 2013, Issue 1; MEDLINE (1948 to January week 4, 2013); EMBASE (1974 to February 2013); CINAHL (1985 to February 2013) and LILACS (1985 to February 2013). We also searched NHS EED, DARE, ClinicalTrials.gov and WHO ICTRP (up to February 2013).

Selection criteria

Randomised controlled trials (RCTs) of chest radiographs versus no chest radiographs in acute LRTIs in children and adults.

Data collection and analysis

Two review authors independently applied the inclusion criteria, extracted data and assessed risk of bias. A third review author compiled the findings and any discrepancies were discussed among all review authors. We used the standard methodological procedures expected by The Cochrane Collaboration.

Main results

Two RCTs involving 2024 patients (1502 adults and 522 children) were included in this review. Both RCTs excluded patients with suspected severe disease. It was not possible to pool the results due to incomplete data. Both included trials concluded that the use of chest radiographs did not result in a better clinical outcome (duration of illness and of symptoms) for patients with acute LRTIs. In the study involving children in South Africa, the median time to recovery was seven days (95% confidence interval (CI) six to eight days (radiograph group) and six to nine days (control group)), P value = 0.50, log-rank test) and the hazard ratio for recovery was 1.08 (95% CI 0.85 to 1.34). In the study with adult participants in the USA, the average duration of illness was 16.9 days versus 17.0 days (P value > 0.05) in the radiograph and no radiograph groups respectively. This result was not statistically significant and there were no significant differences in patient outcomes between the groups with or without chest radiograph.

The study in adults also reports that chest radiographs did not affect the frequencies with which clinicians ordered return visits or antibiotics. However, there was a benefit of chest radiographs in a subgroup of the adult participants with an infiltrate on their radiograph, with a reduction in length of illness (16.2 days in the group allocated to chest radiographs and 22.6 in the non-chest radiograph group, P < 0.05), duration of cough (14.2 versus 21.3 days, P < 0.05) and duration of sputum production (8.5 versus 17.8 days, P < 0.05). The authors mention that this difference in outcome between the intervention and control group in this particular subgroup only was probably a result of "the higher proportion of patients treated with antibiotics when the radiograph was used in patient care".

Hospitalisation rates were only reported in the study involving children and it was found that a higher proportion of patients in the radiograph group (4.7%) required hospitalisation compared to the control group (2.3%) with the result not being statistically significant (P = 0.14). None of the trials report the effect on mortality, complications of infection or adverse events from chest radiographs. Overall, the included studies had a low or unclear risk for blinding, attrition bias and reporting bias, but a high risk of selection bias. Both trials had strict exclusion criteria which is important but may limit the clinical practicability of the results as participants may not reflect those presenting in clinical practice.

Authors' conclusions

Data from two trials suggest that routine chest radiography does not affect the clinical outcomes in adults and children presenting to a hospital with signs and symptoms suggestive of a LRTI. This conclusion may be weakened by the risk of bias of the studies and the lack of complete data available.

PLAIN LANGUAGE SUMMARY

Chest X-rays in acute chest infections

Acute chest infections (lower respiratory tract infections) such as pneumonia, bronchitis and bronchiolitis are a major cause of deaths worldwide and expected to be amongst the leading four causes of death by 2030. The most affected population groups are children under 59 months and adults over 50 years of age. Patients with chest infections often have a fever, cough, shortness of breath and phlegm production. A chest X-ray is commonly used to help diagnose and manage chest infections and is widely used in high-income countries. However, the impact of chest X-rays in terms of how they may change patient recovery in suspected chest infection has not been evaluated. We focused on whether the use of chest X-rays compared to not using them led to improved outcomes such as a faster recovery rate, less time in hospital and fewer complications for the patient. We did not investigate the use of chest X-rays as a tool in the diagnosis of chest infections or the differences in the interpretation of X-rays between doctors.

Two trials with a total of 2024 participants were included in this review. The trial published in 1983 in the USA included only adults, while the trial in 1998 in South Africa included only children. Both trials were set in large metropolitan cities. We were unable to combine the results of the two studies due to incomplete data. However, both trials came to the same conclusion regarding the use of chest X-rays in chest infections, except in the subgroup of patients with evidence of infection (infiltrates) on their X-rays. In both adults and children, chest X-rays did not result in significant differences in recovery time.

In summary, there were no differences in patient outcomes between the groups with or without chest X-ray. Although both studies suggest that chest X-rays do not improve patient outcomes, it is not clear if this finding can be applied to all populations and settings. Results may be different in resource poor countries. Our conclusions are limited due to the lack of complete data available and by the risk of bias of the studies. Adverse effects of chest X-rays were not assessed by either study. We assessed the quality of the evidence from both trials as being moderate. For the remainder of this review, X-rays will be referred to as radiographs.

The evidence is current as of February 2013.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

The effectiveness of chest radiographs in addition to clinical judgement compared with clinical judgement alone for acute lower respiratory tract infections

Patient or population: adults and children with clinical signs and symptoms of acute lower respiratory tract infection
Settings: South Africa and USA
Intervention: chest radiographs and clinical judgement
Comparison: clinical judgement alone, without the use of chest radiographs

Outcomes		Illustrative comparative risks* (95% CI)		No. of participants (studies)	Quality of the evidence (GRADE)	Comments
		Without chest radiograph (control)	With chest radiograph			
Mortality	**Adults**	-	-	-	-	Not assessed
	Children	0	0	518 (1)	⊕⊕⊕◯ **moderate**	Not included as an outcome, however it was reported that "no deaths were recorded" during the trial
Time to resolution of clinical signs and symptoms [days]	**Adults**	17.0	16.9	1502 (1)	⊕⊕◯◯ **low**	Average duration of illness in the radiograph group was 16.9 days and 17.0 days in the no radiograph group (P > 0.05) Relative risks not provided in original RCT Inadequate data provided in original RCT - further analysis of these data could not be conducted as a specific P value was not stated (only whether the P value was greater or less

						than 0.05) Follow-up continued to either end of illness or for at least 1 month after presentation Downgraded to low quality due to risk of bias and the lack of evidence that the estimate excludes clinically meaningful differences in either direction
	Children	7 (95% CI 6 to 9)	7 (95% CI 6 to 8)	518 (1)	⊕⊕◯◯ **low**	Median time to recovery in control group was 7 days (95% CI 6 to 9 days) and in the chest radiograph group was 7 days (95% CI 6 to 8 days) P = 0.50, log-rank test Hazard ratio for recovery was 1.08 (95% CI 0.85 to 1.34) Follow-up until recovery or censored at 28 days Downgraded to low quality due to risk of bias and the lack of evidence that the estimate excludes meaningful differences in either direction
Hospitalisation rates	**Adults**	-	-	-	-	Not reported. Data only provided in subgroup of patients that was not randomised

	Children	2.3% (6 of 261 children)	4.7% (12 of 257 children)	518 (1)	⊕⊕◯◯ **low**	The estimated risk ratio for this study was 2.03 (0.77 to 5.03). Not statistically significant (P = 0.154) Downgraded to low quality due to risk of bias and imprecision of data
Complications of infection	**Adults**	-	-	-	-	Not assessed
	Children	-	-	-	-	Not assessed
Adverse effects from chest radiographs	**Adults**	-	-	-	-	Not assessed
	Children	-	-	-	-	Not assessed

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: confidence interval; **P:** P value; **NNT:** number needed to treat; **RCT:** randomised controlled trial; **RR:** risk ratio

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

Bushyhead 1983: limitations in the design and implementation of available studies suggesting high risk for detection bias and low or unclear risk for selection, attrition and reporting bias (Risk of bias in included studies).
Swingler 1998: limitations in the design and implementation of the study suggesting high risk for selection and attrition bias and low risk for detection and reporting bias (Risk of bias in included studies).
No serious risk of unexplained heterogeneity or publication bias in either of the trials. Both outcomes for time to resolution of symptoms and hospitalisation rates in both trials were downgraded to 'low quality' due to imprecision of results.
A column for relative effects was not included as part of the 'Summary of findings' table as data needed to calculate relative risks were not presented in either of the included trials.
Although mortality in children did not occur, we have included this in our Summary of findings for the main comparison as it may reflect the severity of illness and the use of appropriate management.

BACKGROUND

('Lower respiratory tract infections' are referred to as 'chest infections' in the 'Plain language summary').

Description of the condition

Lower respiratory tract infections (LRTIs) are infections that occur below the level of the larynx and include pneumonia, bronchitis and bronchiolitis. These tend to be more severe in nature than upper respiratory tract infections (infections above the level of the pharynx). In this review we will only focus on LRTIs.

LRTIs are the third leading cause of death worldwide after coronary heart disease and stroke, and are expected to be amongst the leading four causes of death by 2030, with pneumonia accounting for a significant proportion (WHO 2004). According to the World Health Organization (WHO), there were 3.2 million deaths worldwide in 2011 due to LRTIs, with 1.1 million deaths in the African region alone (WHO 2011). The most affected population groups were children under 59 months of age and adults over 50 years of age (WHO 2011).

Pneumonia is referred to as the inflammation of one or both lungs with consolidation and is classified by the causative organism, such as bacteria, virus, fungi or protozoa (WHO 2013; Yang 2013). Between 2004 and 2005, the hospitalisation rate for pneumonia in England was 1.98 per 1000 population (Trotter 2008). It is the leading cause of mortality in children less than five years of age (Lodha 2013). The diagnosis and management of this condition is associated with significant costs (Bjerre 2009). Complications may include effusion, empyema, abscess, sepsis and lung failure resulting in death (Mandell 2007).

Bronchitis is the inflammation and irritation of the trachea and bronchi. It is caused by viral or bacterial pathogens as well as respiratory irritants such as dust or fumes. Nearly all cases of acute bronchitis are self limiting (Smith 2011). In Australia this respiratory disorder is the fifth most common presentation to General Practitioners (Wark 2008). Chronic bronchitis refers to a productive cough for at least three months of each of two successive years for which other causes have been ruled out (WHO 2013). Chronic bronchitis is mostly linked to longstanding conditions such as emphysema and asthma. In 2007, 4.4% of adults were diagnosed with chronic bronchitis in the USA (Pleis 2008).

Bronchiolitis is a virally induced acute bronchiolar inflammation associated with airway obstruction that affects infants younger than two years of age. The severity of the disease can range from mild to severe, and clinically manifests with rhinorrhoea, expiratory wheezing and a cough (Lozano 2007). The most common viral cause is respiratory syncytial virus (Roqué i Figuls 2012). Although it can be a life-threatening illness, the mainstay of treatment is supportive care and there is no clear evidence for the effectiveness of antibiotics (Spurling 2011).

Description of the intervention

Chest radiographs are routinely used as a tool to diagnose and screen for acute respiratory tract infections of the lower respiratory system including pneumonia, tuberculosis, bronchiolitis and emphysema. For example, community-acquired pneumonia is diagnosed based on the presence of pulmonary infiltrate on chest radiographs and the clinical signs and symptoms of the patient (Ruiz 2000). However, in practice there appears to be an "undue reliance on the clinical diagnosis of community-acquired pneumonia" and a chest radiograph may be done only when the diagnosis is uncertain (Mandell 2010).

Management of many LRTIs, especially pneumonia, focuses on the early detection and treatment of the disease. Chest radiographs are one of the commonly used strategies. However, it has been suggested that there can be substantial differences in their interpretation by clinicians and radiologists (Hopstaken 2004). This review focuses on the efficacy of chest radiographs in treating LRTIs and therefore we will not include studies on other strategies such as computed tomography (CT) or on the inter-observer differences in interpretations of chest radiographs.

How the intervention might work

Chest radiographs are used as an investigation to confirm or refute possible diagnoses. They are an objective measure which can not only confirm a suspected disease such as pneumonia but can also define the severity, for example, multiple lung lobes and any associated complications such as pleural effusions and cavitations (ATS 2005). Chest radiographs are accepted as the gold standard in the diagnosis of pneumonia (Woodhead 2005). However, there is no clear radiological definition for the diagnosis of pneumonia, rather a spectrum of radiological appearances ranging from multifocal lobular consolidation to diffuse interstitial changes (Gharib 1990). Conversely, different diseases may appear similar radiologically, for example, bacterial pneumonia, pulmonary tuberculosis in HIV-positive people and pneumocystis carinii pneumonia (Boiselle 1997). Although the presence of radiographic findings is highly suggestive of a diagnosis, an absence of findings does not necessarily preclude the disease (Basi 2004).

Why it is important to do this review

Although chest radiographs are routinely used in the management of acute LRTIs, the efficacy of this diagnostic tool in their treatment has not been determined. This is important for clinicians to know so that unnecessary chest radiographs will not be ordered. This will decrease healthcare costs for the patient on an individual level and ensure better allocation of healthcare resources and funding on a population level. Furthermore, the cumulative effect of radiation from multiple chest radiographs could potentially lead to the development of malignant conditions or cause or exacerbate

pre-malignant processes. This review aims to address this issue so that clinicians can weigh up the potential benefits and harms of using chest radiographs in order to achieve the best outcome for patients. We specifically focus on the use of radiographs as a clinical tool for management rather than their use as a diagnostic tool. We did not investigate the inter-observer differences in interpretation of the radiographs between clinicians or radiologists, or both.

OBJECTIVES

To assess the effectiveness of chest radiographs in addition to clinical judgement, compared to clinical judgement alone, in the management of acute LRTIs in children and adults.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs). As double-blinding is not feasible, open studies and studies with outcome assessor blinding were eligible.

Types of participants

Adults and children with clinical signs and symptoms of an acute LRTI, for example, cough, fever, dyspnoea, feeling generally unwell, etc.

Types of interventions

Chest radiograph (posterior-anterior and lateral views) compared with no chest radiograph prior to initiation of management.

Types of outcome measures

Primary outcomes

1. Mortality.
2. Time to resolution of clinical signs and symptoms (patient's presenting symptoms and findings on physical examination such as reduced breath sounds, crackles, dull percussion note, etc.).

Secondary outcomes

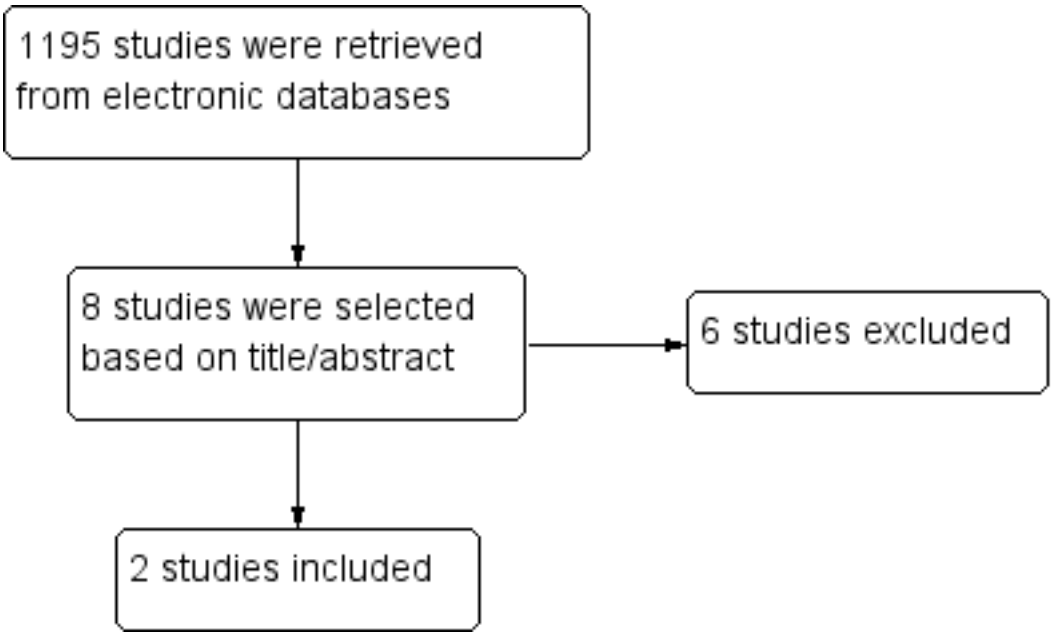
1. Hospitalisation rates.
2. Any complications of the infection (for example, abscess, pleural effusion, septicaemia, respiratory failure).
3. Adverse effects from chest radiographs (for example, malignant conditions).

Search methods for identification of studies

Electronic searches

We searched the Cochrane Central Register of Controlled Trials (CENTRAL) 2013, Issue 1, part of *The Cochrane Library*, www.thecochranelibrary.com (accessed 5 February 2013), MEDLINE (1948 to January week 4, 2013), EMBASE (1974 to February 2013), CINAHL (1981 to February 2013) and LILACS (1982 to February 2013). See Figure 1.

Figure 1. Flow diagram of study selection and inclusion.



We used the following search strategy to search MEDLINE and CENTRAL. We combined the MEDLINE search with the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE (Appendix 1): sensitivity- and precision-maximising version (2008 revision); Ovid format (Lefebvre 2011). We adapted the search strategy to search EMBASE (Appendix 2), CINAHL (Appendix 3), LILACS (Appendix 4), ClinicalTrials.gov (Appendix 5) and WHO ICTRP (Appendix 6).

Searching other resources

We searched DARE and NHS EED 2013, Issue 1, part of *The Cochrane Library*, www.thecochranelibrary.com (accessed 5 February 2013) to identify any relevant systematic reviews in order to check the reference lists for randomised trials. We also searched ClinicalTrials.gov on 19 February 2013 and the World Health Organization International Clinical Trials Registry Platform (WHO ICTRP) on 23 February 2013. We handsearched the reference lists of RCTs for additional studies, searched the trial registers for ongoing or recent trials and contacted experts in the field about any unpublished or ongoing studies. We contacted Professor GH Swingler who was the author of both Swingler 1998 and the original Cochrane Review Swingler 2008 in order to obtain additional data when there was insufficient information reported in the publication of the included trial or missing relevant data. We did not apply any publication, time or language restrictions in our search.

Data collection and analysis

All review authors independently performed study selection. All review authors assessed studies for trial quality and extracted data.

Selection of studies

Two review authors (AC, JC) independently assessed and evaluated potential studies for inclusion in this review. One review author (LM) independently evaluated any disagreements and discrepancies (with guidance from MLvD) and all review authors discussed results until a consensus was reached.

Data extraction and management

Two authors (AC, JC) independently collected and extracted the data from the studies. A third review author (LM) resolved any disagreements through further discussion with all review authors until a consensus was reached. We described the data extracted in the Characteristics of included studies table.

Assessment of risk of bias in included studies

We assessed the risk of bias by evaluating whether there was adequate random sequence generation, allocation concealment, blinding of outcome assessment, if incomplete outcome data were discussed for short and longer-term outcomes and whether studies were free of selective reporting and other bias, for example, conflict

of interest of authors, publication bias, etc. (Higgins 2011). We assessed the following potential sources of bias as 'low risk', 'high risk' or 'unclear' (if insufficient information was available to make a clear judgement):

- selection bias, i.e. sequence generation and allocation concealment;
- performance and detection bias, i.e. blinding of participants and personnel;
- detection bias, i.e. blinding of outcome assessment;
- attrition bias, i.e. incomplete outcome data;
- reporting bias, i.e. selective reporting;
- other sources of bias, for example, setting, conflict of interest of authors, publication bias.

Measures of treatment effect

We presented dichotomous data, such as mortality, as a risk ratio (RR) with 95% confidence intervals (CIs). We expressed the estimate of clinical effect as numbers needed to treat to benefit (NNTB). We presented continuous data as mean differences (MDs) with their standard deviations (SDs).

Unit of analysis issues

We included studies where the unit of analysis is the unit of randomisation. We did not identify any cluster-RCTs and therefore did not need to apply adjustment as outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

Dealing with missing data

We contacted Professor GH Swingler who was the author of this original review (Swingler 2008) via email for additional data (NNTB at 14 days) that was published in the original review but not published in the trial Swingler 1998. Unfortunately, the original unpublished data could not be found. As additional outcome data were not available, we performed intention-to-treat (ITT) analysis. In ITT analysis patients for whom outcome data were missing are considered as treatment failures for the meta-analysis.

Assessment of heterogeneity

We assessed heterogeneity in a two-stepped process. We first assessed similarities at face value (for example, similar setting, participant population, randomisation method). Secondly, we assessed statistical heterogeneity by using the Chi^2 test with a P value of < 0.10 as a cut-off for statistical significance and the I^2 statistic with a cut-off value of 40% as indicating important heterogeneity as outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). In the presence of heterogeneity we did not pool the studies (face value heterogeneity) or used a random-effects model (presence of statistical heterogeneity). In the absence of heterogeneity we used a fixed-effect model (Higgins 2011).

Assessment of reporting biases

We planned to perform a funnel plot analysis to assess the presence of publication bias. However, an insufficient number of studies (i.e. fewer than 10) were identified for this review. We reported the conflict of interest declarations of the trial authors where available. We assessed detection bias, i.e. if there was blinding of outcomes assessment for the assessors and the patients. We also assessed attrition bias, i.e. if the withdrawals were described and if an ITT analysis was performed.

Data synthesis

We synthesised data from the RCTs using Review Manager (RevMan 2012) software.

Subgroup analysis and investigation of heterogeneity

We planned to investigate the following subgroups.

1. Infants under two years versus older children.
2. Adults versus elderly (aged > 65 years).
3. Early versus later chest radiograph (i.e. before or after 48 hours since start of symptoms).
4. ITT analysis versus on-treatment analysis.

We attempted to obtain individual data from authors of included studies to attempt individual patient data meta-analysis; unfortunately no individual patient data were available for meta-analysis.

Sensitivity analysis

We planned to perform sensitivity analyses by investigating the impact of risk of bias and heterogeneity on the overall estimate of effect. We first pooled studies with a low risk of bias and subsequently added studies with a high risk of bias in order to assess the impact of risk of bias on the overall outcome. In order to investigate the impact of heterogeneity on the overall estimate of effect we had planned to remove studies that seemed (by inspecting the forest plot and identifying the 'outliers') to contribute to heterogeneity and compared the overall outcomes. However, due to the lack of data and the limited number of included trials this was not possible.

RESULTS

Description of studies

See Figure 1 for a breakdown of study search results and included studies.

We contacted Professor GH Swingler, the author of both Swingler 1998 and the original Cochrane Review Swingler 2008 to obtain unpublished data that was not reported in the original trial

(Swingler 1998) but was included as part of the results in the original Cochrane Review (Swingler 2008). However, Professor Swingler was not able to locate the data from which the calculations (numbers needed to treat) were derived. We have not included these unpublished data as they could not be verified.

Results of the search

Searching the electronic databases retrieved a total of 1195 records after duplicates were removed. There were 582 records retrieved from the MEDLINE search, 71 records retrieved from CENTRAL, 345 records from EMBASE, 136 records from CINAHL, 53 records from LILACS, none from DARE, one record from NHS EED, four records from ClinicalTrials.gov and three records from WHO ICTRP (Figure 1).

Included studies

Of the 1195 studies found, eight appeared to be relevant to our review (Bourayou 2011; Briel 2006; Bushyhead 1983; Colucci 2012; Lynch 2004; Ralston 2012; Swingler 1998; Swingler 2000). After further analysis, two studies were included in our review (Bushyhead 1983; Swingler 1998). The other six studies were excluded (Bourayou 2011; Briel 2006; Colucci 2012; Lynch 2004; Ralston 2012; Swingler 2000).

Design

Both included trials were RCTs.

Sample size and setting

Bushyhead 1983 enrolled 2018 participants, was conducted in the emergency room and walk-in clinic of an Army Medical Centre in Texas, USA and consisted of three phases. However, only Phase III was relevant to our review and, thus, only Phase III was analyzed. Phase III included 1502 adults (1531 enrolled but 29 were excluded). Swingler 1998 included 522 children (581 enrolled but 59 were excluded) and was conducted in a children's teaching hospital in South Africa (Red Cross Children's Hospital).

Participants

Participants in Bushyhead 1983 were adult, non-pregnant, mainly retired, military personnel and their dependents with a small proportion being active duty army troops. Patients with a cough lasting less than one month at the first presentation were included in the trial. Patients who had a pulse rate of 160 or more, temperature 104 °F (40 °C) or more, systolic blood pressure 90 mmHg or lower or patients arriving by stretcher were excluded from the trial. Participants in Swingler 1998 were children aged between 2 and 59 months old who met the WHO case definition for pneumonia. Excluded participants in Swingler 1998 included children presenting with a "cough of more than 14 days duration, history of current household contact with active tuberculosis, a localised wheeze, clinical signs of cardiac failure or [when] the clinician's assessment that a chest radiograph was mandatory".

Interventions

The Bushyhead 1983 trial was divided into three phases. In Phase I, chest radiographs were only taken on physicians' request and all requested radiographs were seen by all physicians (n = 199), resembling practice as usual. In Phase II, chest radiographs were taken of all patients but physicians only saw the films if they had ordered them (n = 288). Phase III was the largest phase of the study with 1502 participants. In Phase III, chest radiographs were taken of all patients and it was determined by lot with 1:1 odds randomisation whether physicians would receive the radiology report and film. Physicians recorded their diagnosis and management plan as well as their prediction of the most likely finding on the chest radiograph, prior to being told if they could see the chest radiograph. They also noted if they wished to order a chest radiograph for each patient. Physicians were allowed to change the diagnosis and management plans only if their patient was allocated to the chest radiograph group.

In the Swingler 1998 trial, children were randomly allocated to have chest radiographs (both anteroposterior and lateral views) or no chest radiograph. The chest radiographs were seen by the clinician and a report was available with the films. The control intervention was standard care without a chest radiograph.

Outcomes

Bushyhead 1983 investigated the effect of chest radiographs on the management and clinical course of patients with a cough. However, their primary objective was to investigate whether the use of providing chest radiographs influenced the physician's decisions, i.e. the addition of antibiotics, changes in management plans and also illness outcomes (e.g. returned visits, hospitalisation time, duration of symptoms and illness).

Swingler 1998 investigated the "effect of chest radiographs on the management and clinical outcome in children with ambulatory acute lower respiratory [tract] infection" with the primary outcome measure being the time to recovery. Subsidiary outcomes included other management options used such as antibiotics and admission to hospital.

Excluded studies

We excluded six studies (Bourayou 2011; Briel 2006; Colucci 2012; Lynch 2004; Ralston 2012; Swingler 2000). Bourayou 2011 was a literature review on the diagnostic value of chest radiography rather than the use of chest radiographs as a management tool in LRTIs. Briel 2006 investigated how test results affected management decisions but did not distinguish between the use of chest

radiographs and other blood tests and data for chest radiographs only could not be extracted. Although the objective of Colucci 2012 was to determine whether the management of pneumonia correlated to radiography, it was excluded because it was retrospective. Lynch 2004 was excluded because its primary outcome was irrelevant to our review. Lynch 2004 aimed to investigate the "difference in sensitivity and specificity of the emergency physicians' interpretations of chest radiographs". Ralston 2012 was excluded as it was not a RCT and because its objective was for quality control by reducing interventions for acute viral bronchiolitis. Swingler 2000 was excluded because it appeared to be a duplication of the Swingler 1998 study but with an emphasis on case finding for tuberculosis. No ongoing studies or studies awaiting classification were identified.

Risk of bias in included studies

A visual summary of the risk of bias in the included studies is presented in Figure 2 and Figure 3.

Figure 2. 'Risk of bias' graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

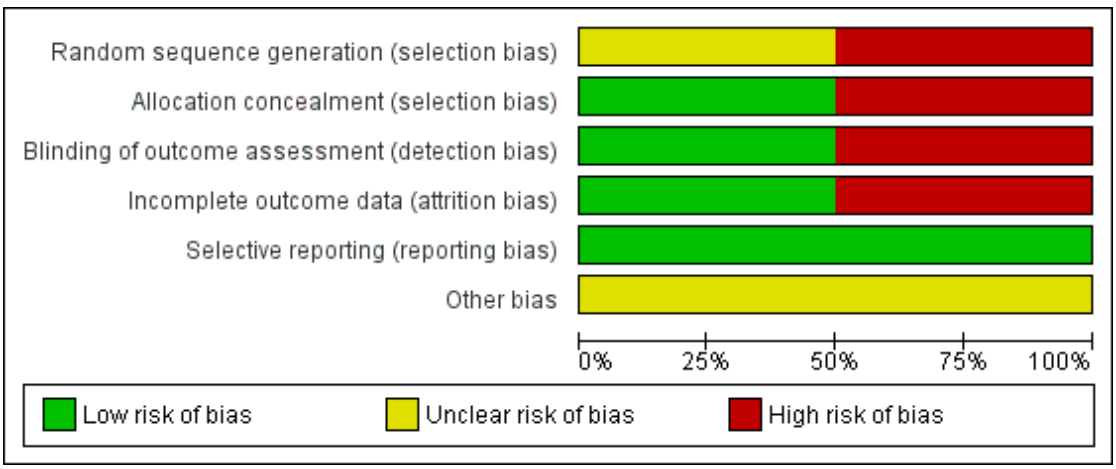
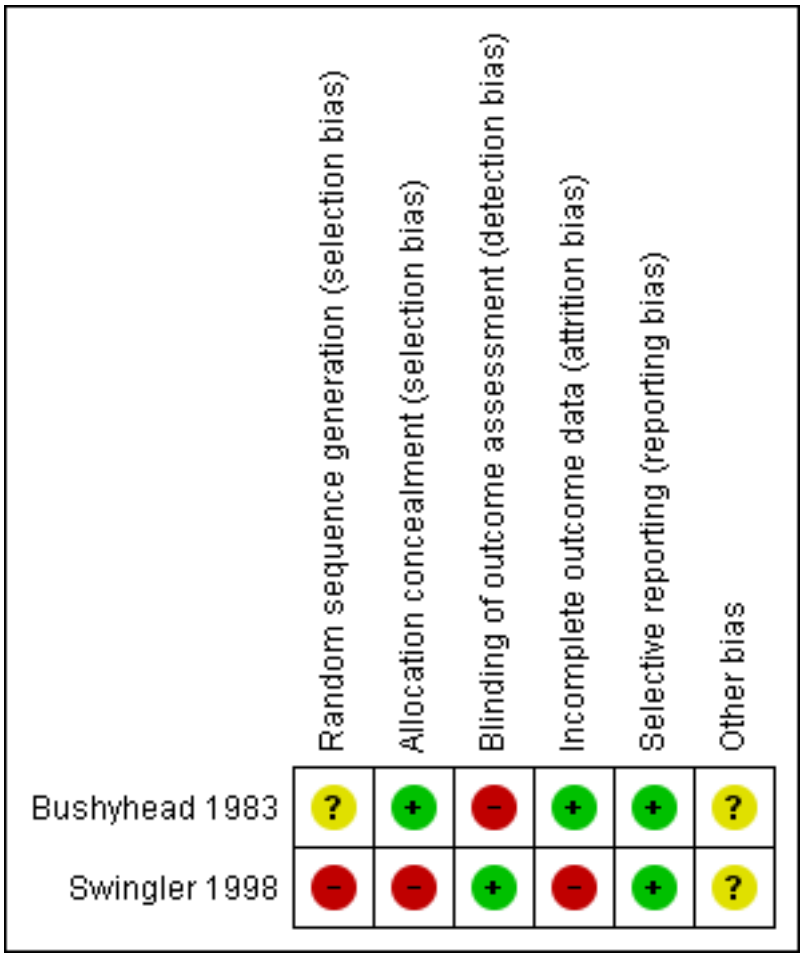


Figure 3. 'Risk of bias' summary: review authors' judgements about each risk of bias item for each included study.



Allocation

In the Swingler 1998 trial, the principal investigator generated the random numbers by tossing a coin for each sequentially numbered envelope. A study nurse identified eligible patients who were subsequently seen by the clinician. For each eligible patient, a sequentially numbered "manila envelope" containing the random allocation was attached to the consultation sheet. The clinician was blinded to the content of the envelope prior to opening it. If a patient was withdrawn before randomisation, the envelope was returned to the investigator and this was audited. Thus, the risk of selection bias for this trial is high.

In Phase III of the Bushyhead 1983 trial, the random sequence generation was described as "determined by lot with 1:1 odds" who would receive the chest radiographs and the radiologist's report. However, it was not described how the random numbers or "lots" were generated, who did this and how it was communicated to the participating physicians. Thus, the risk of bias is unclear. Regarding the allocation concealment in Phase III of the trial, "we required clinicians to record diagnoses and management plans for all patients before they knew whether or not they would see the chest films...They noted whether they wished to order a chest radiograph for the patient and if so, why. These decisions had no bearing on whether the physicians saw the radiographs." Therefore, the risk of bias for allocation concealment for Phase III of the trial is low.

Blinding

In Bushyhead 1983, the research assistants who collected a standard history from all patients at inclusion were blinded to the

randomisation status of the patient. The chest radiographs were read by radiologists who were unaware of the patient's clinical presentation other than that they had an acute cough. The effect on patient outcomes (duration of illness and disability) was assessed by research assistants who contacted the participants by telephone every four weeks. However, assessment of secondary outcomes was not blinded and therefore the risk of detection bias is high.

In Swingler 1998, the primary outcome (time to recovery) was assessed by research assistants who contacted the participants by telephone twice weekly. The telephone interviewer was blinded to the randomisation status of the patient on follow-up but also to the study objectives. The principal investigator examined the clinical records of all patients to ascertain all other outcomes. Coding of the collected data from the telephone interviews was performed by the principal investigator who had no knowledge of the group the patients were allocated to and was entered in a separate database. Therefore, the risk of detection bias is low.

Incomplete outcome data

In both trials, all participants were accounted for and also ITT analysis was performed. In Bushyhead 1983, 2% of patients were excluded from randomisation as physicians felt that viewing the chest films was needed to evaluate their condition. There were four patients lost to follow-up in Bushyhead 1983. However, three were patients with masses and the other one presented with weight loss. It would have been unlikely for this to have affected the overall outcome of the study.

Swingler 1998 attempted to follow-up a subset (365 participants) of the total number of participants (581) enrolled. Of this subset, 22% were lost to telephone follow-up. Although it was mentioned that the loss was similar between treatment groups, this is nonetheless a significant proportion of patients that were lost to follow-up.

Selective reporting

For both studies, there were no trial protocols available to us. However, in both Bushyhead 1983 and Swingler 1998 all outcomes were reported. Thus, we considered both trials to have low risk of selective reporting.

Other potential sources of bias

In the Bushyhead 1983 study, only patients who verbally agreed to the Phase III protocol were included in Phase I of the study. Although this aimed to ensure the study population in those two phases would be comparable, whether this would have significantly altered the selected patient population is unclear.

No other potential sources of bias were identified in either trial (e.g. baseline imbalance, deviation from study protocols in a way that does not reflect clinical practice, pre-randomisation of interventions). Neither Bushyhead 1983 nor Swingler 1998 reported conflicts of interest or financial disclosures. However, Swingler 1998 "was supported by the Medical Research Council of South Africa and the University of Cape Town." No further information regarding the method in which the Medical Research Council of South Africa and the University of Cape Town supported this study was provided. Therefore, the risk of bias for both studies is unclear.

Effects of interventions

See: **Summary of findings for the main comparison**

Refer to Summary of findings for the main comparison.

Primary outcomes

1. Mortality

This outcome was not assessed by the studies included in this review. However, Swingler 1998 states that "no deaths were recorded" during the trial (followed up for 28 days).

2. Time to resolution of clinical signs and symptoms

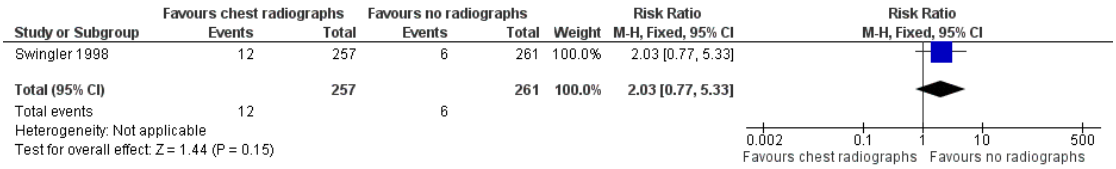
Both studies included in this review (Bushyhead 1983; Swingler 1998), with a total of 2024 participants (1502 adults in Phase III of Bushyhead 1983 and 522 children in Swingler 1998), assessed time to resolution of clinical signs and symptoms (Analysis 1.1).

In Bushyhead 1983, the overall length of illness was 16.9 days in the group with chest radiographs compared to 17.0 days in the group without a provided radiograph ($P > 0.05$). There were also no statistically significant differences in the average duration of symptoms between the two groups. Duration of cough was 15.0 days when radiographs were provided and 15.2 days when they were not provided. Duration of sputum production was 10.0 days with radiographs compared to 10.5 days without radiographs. Duration of fever was 0.44 days compared to 0.64 days when radiographs were not given to the physicians. Duration of reported fatigue was 5.4 days compared to 4.9 days. In patients with infiltrates ($n = 41$), however, use of the chest radiograph was associated with a reduction in the length of illness (16.2 days in the group allocated to chest radiographs and 22.6 in the non-chest radiograph group, $P < 0.05$), duration of cough (14.2 versus 21.3 days, $P < 0.05$) and duration of sputum production (8.5 versus 17.8 days, $P < 0.05$). The authors mention that this difference in outcome between the intervention and control group was probably a result of "the higher proportion of patients treated with antibiotics when the radiograph was used in patient care." Further analysis of these data could not be conducted as a specific P value (rather than one that was greater or less than 0.05) for the average duration of symptoms was not stated.

In Swingler 1998, 295 out of the 522 participants could be contacted by telephone enabling follow-up until recovery or were censored at 28 days. "The median time to recovery was 7 days for

both groups (95% confidence interval (CI) 6 to 8 days in the radiograph group and 6 to 9 days in the control group, P = 0.50, log-rank test)." (Figure 4). However, as only the median was reported and no mean for these data was stated, further analysis was not possible (Table 1). The hazard ratio for recovery was 1.08 (95% CI 0.85 to 1.34). Additional unpublished data from Swingler 1998, which were published in Swingler 2008, showed that the "relative risks for remaining ill at four and 14 days were 0.01 (95% CI 0.78 to 1.07) and 0.85 (95% CI 0.53 to 1.37) respectively".

Figure 4. Forest plot of comparison: 1 Chest radiograph versus management without chest radiograph (children only), outcome: 1.2 Hospitalisation rates.



Secondary outcomes

1. Hospitalisation rates

In Bushyhead 1983, hospitalisation rates were not reported. Data for hospitalisation rates were only provided for the subgroup of patients for whom their treating doctor insisted on chest radiography. This subgroup was not randomised and is not included in our review.

In Swingler 1998, a higher proportion of patients randomised to the intervention group (4.7%) required hospitalisation compared to the comparator group (2.3%) (Analysis 1.2). However, this result was not statistically significant (P = 0.14) (Figure 4).

2. Complications of infection

This outcome was not assessed by the studies included in this review.

3. Adverse effects from chest radiographs

This outcome was not assessed by the studies included in this review.

DISCUSSION

Summary of main results

Our review found two trials that investigated the effect of chest radiographs in lower respiratory tract infections (LRTIs); one in adults (Bushyhead 1983) and one in children (Swingler 1998). Severely ill patients were excluded from both randomised controlled trials (RCTs). Both trials came to the conclusion that making chest radiograph results available to clinicians resulted in similar outcomes for patients with acute LRTIs compared to when no chest radiograph results were available.

For cases in adults, Bushyhead 1983 states that the differences in outcomes between the group with chest radiographs and the group without were not statistically significant. This suggests that chest radiographs did not result in significant changes in management plans or differences in patient outcomes. However, chest radiographs appear to be of benefit in the subgroup of the participant population with an infiltrate on their radiograph. In this subgroup of patients whose chest radiographs showed infiltrative abnormalities, the "use of the chest radiograph was associated with [a] reduction in the length of illness, duration of cough, and duration of sputum production (P < 0.05)". This effect was not evident in patients whose chest radiographs showed non-infiltrate radiographic abnormalities. It was interesting to note that although patients with non-infiltrate radiographic abnormalities often had additional return visits, diagnostic tests and changes in treatment, these changes were rarely effective, i.e. rarely led to improved patient outcomes. Bushyhead 1983 reported that "chest radiographs were not ordered efficiently by physicians". It is also interesting

to note that only 54% of patients with infiltrates on chest radiographs would have had chest radiographs ordered by the treating physician under normal practice conditions. None of the other 46% of patients would have been suspected to have pneumonia despite definite radiographic infiltrates. Nonetheless, this finding has limited practical implications as, to date, the simplest and most accessible way of knowing whether patients will have pulmonary infiltrates is to perform a chest radiograph.

For cases in children, Swingler 1998 states that "there are no clinically identifiable subgroups of children within the WHO case definition of pneumonia who are likely to benefit from a chest radiograph." Swingler 1998 summarised that "the most favourable 95% CI for the estimate of benefit of a chest radiograph is the prevention of 3 days of relatively trivial symptoms, while the least favourable is the cause of an additional 2 days of symptoms". It was thought-provoking to note that at 28 days, every 11 chest radiographs performed in children would result in one more antibiotic script (95% CI -5.8 to 61.7). Additionally, every 42 chest radiographs performed at 28 days would lead to one additional hospital admission (95% CI -18 to 127). Swingler 1998 concluded that "the use of chest radiographs did not reduce time to recovery or subsequent health-facility use in children over two months with ambulatory acute lower-respiratory [tract] infection" and hence recommended that "chest radiographs should not be routinely done in this group of patients" (Figure 4).

According to Swingler 1998, the effect of chest radiographs was independent of both the severity of the respiratory tract infection and the clinician's clinical experience. The patient's "age, weight for age, duration of symptoms before presentation, respiratory rate, or the clinicians' perception of the need for a radiograph" did not influence the effect of the chest radiograph. This effect is also not influenced by the clinicians' qualifications or experience, i.e. whether they were recently qualified doctors with no previous paediatric outpatient experience or had a postgraduate paediatric qualification.

With regard to hospitalisation rates, Swingler 1998 reported higher hospitalisation rates for patients randomised to chest radiographs but this result was not statistically significant (Figure 4). Unfortunately, Bushyhead 1983 did not analyze hospitalisation rates for patients whose radiographs were provided versus those for whom radiographs were not provided, which is one of the objectives of our review. Instead Bushyhead 1983 reported hospitalisation rates in the group of patients whose radiographs were provided to their physicians and compared whether the wishes of the physician to view the radiograph or not had an impact on the patients' hospitalisation rates.

Both RCTs set strict exclusion criteria that excluded patients with suspected severe disease, either based on variations in patients' vital signs, other clinical signs of severe disease such as localised wheeze or when the clinicians' assessment deemed chest radiographs mandatory. Strict exclusion criteria are important but may limit the clinical practicability of the results of the trials as both study populations were well-filtered sample populations which may not reflect those presenting in clinical practice.

There were no data available from the included studies to assess the impact on mortality, complications of infection and adverse effects from chest radiographs. Swingler 1998 briefly comments on the potential drawbacks of ordering chest radiographs. However, no data regarding this were collected in either of the included studies. Listed disadvantages of chest radiographs in Swingler 1998 include the "exposure of ionising radiation, cost (especially if travel to another facility is necessary), the time and space used waiting for the radiograph and the need to be seen again by a clinician". Theoretical long-term complications of radiation exposure from chest radiographs, such as risk of malignancy later in life, were not discussed. Statistics show that the radiation exposure from the use of chest radiographs is extremely low; a chest radiograph in two views is associated with an effective dose of ionising radiation of 0.06 to 0.25 mSV (Diederich 2000). This is in comparison to the average background radiation dose of around 2.4 mSV per year (WNA 2011). This means that at its most, one chest radiograph would be equivalent to approximately one month of background radiation, i.e. there is essentially a negligible risk of malignancy in the long term with a single chest radiograph.

Another feature of chest radiographs that is worth mentioning is the discovery of incidental findings, which may be advantageous or disadvantageous. For example, in Bushyhead 1983 there were 17 intrathoracic masses detected, six of which were absent on follow-up radiographs and the remainder proving to be acute infiltrate, pericardial cyst, hiatus hernia and granulomas. However, one mass proved to be lung cancer in a 74-year old man. Chest radiographs may at times find non-specific nodules which more likely than not are benign but nonetheless require follow-up (Gould 2007). This may mean further investigations such as biopsies to rule out malignancy - these additional tests each have their own associated morbidity. In cases of malignancy found on chest radiographs requested for clinically suspected pneumonia, the malignancy may be the primary cause of the pneumonia (e.g. the tumour causes bronchial obstruction and pneumonia may be the complication of the tumour).

Overall completeness and applicability of evidence

Both of the included studies provided some relevant evidence for the objectives of this review. However, our review included objectives which were not objectives of the included trials and, therefore, there were no results regarding this. One of our primary outcomes was to assess mortality and this was not assessed by either of the studies. Our other primary outcome was to investigate the time to resolution of clinical signs and symptoms. However, given that the reported data are incomplete, results could not be pooled together in a meta-analysis. In addition, our secondary outcome of assessing hospitalisation rates was only reported by Swingler 1998.

Other secondary outcomes, such as complications of infection and adverse effects from chest radiographs, were not assessed by either study. This limits the amount of evidence we could analyze. Furthermore, as the participant population in Bushyhead 1983 were adults whilst the participants in Swingler 1998 were children, extrapolation of these results to come to a general conclusion may be inappropriate and of uncertain validity.

Quality of the evidence

Despite the large number of participants (2024), given that the reported data were incomplete, there is limited evidence to formulate robust conclusions regarding the objectives of our review. We assessed both RCTs as having a high risk of bias with regards to selection bias and likely imprecision of results and, hence, we downgraded them to 'low' based on the GRADE working group grades of evidence (Higgins 2011). Although the results of the two studies could not be pooled into a meta-analysis, both come to the same conclusion regarding the use of chest radiographs in acute LRTIs, except in the subset of patients with infiltrates on their radiograph.

Potential biases in the review process

Identification of all relevant studies

We used a broad search strategy to ensure that we could ascertain all relevant trials which met our criteria. It is possible that we may have missed studies. However, contacting experts in the field did not yield any other relevant references and therefore we think it is unlikely that studies were missed.

Introduction of bias

We independently appraised the studies for inclusion as well as for risk of bias and data extraction in order to minimise the risk of bias in the review process.

Agreements and disagreements with other studies or reviews

We are not aware of any other RCTs or systematic reviews available to compare results with.

AUTHORS' CONCLUSIONS

Implications for practice

The two studies included in our review show that the use of chest radiographs in acute LRTIs did not result in changes in physician management or patient outcomes in both adults and children. However, in the subgroup of patients with infiltrates on their radiograph, use of chest radiographs appears to be of benefit and was associated with a decrease in the length of illness. Unfortunately, in order to identify infiltrates, a chest radiograph needs to be performed. It is important to note however, that the quality of evidence supporting these conclusions is weakened by the lack of complete data available and the risk of bias of the included studies.

Both the included trials were set in large metropolitan cities, Bushyhead 1983 in Texas and Swingler 1998 in Cape Town. Although radiological facilities are easily accessible in high-income countries, in low-income countries, especially in rural areas, access to such resources can be limited (Chudi 2010). There is very limited data on the exact scale of this problem. However, the World Health Organization has estimated that two-thirds of the world's population have no access to diagnostic imaging (Maru 2010; PAHO 2012). In addition to the availability of healthcare facilities, chaotic transportation systems and inaccessible roads further compound the problem (Chudi 2010). Providing medical care without the use of these vital diagnostic imaging modalities poses a risk of delays in diagnoses and timely management. Although the results of this review found no significant difference in patient outcomes between those who had a chest radiograph and those who did not, both studies were set in large cities with relatively easy access to healthcare facilities. The outcomes may be different for patients in a resource poor country or in remote settings with delayed presentation and limited radiological facilities. Both Bushyhead 1983 and Swingler 1998 had strict exclusion criteria which may limit the clinical practicability of the results of the trials as they may not reflect those presenting in clinical practice.

Implications for research

Further research involving both children and adults in remote settings, as well as further exploration of subgroups that might benefit from radiographic imaging (such as patients with infiltrative infections and or co-morbidities), is needed. Data on adverse effects from chest radiographs are currently lacking and require further investigation. In addition, the ability of chest radiographs to identify complications in patients not responding adequately to treatment may be an area of future research.

ACKNOWLEDGEMENTS

This is an update and revision of a previously withdrawn Cochrane Review (Swingler 2008). We would like to acknowledge the work of the previous authors of this review, George H. Swingler and

Merrick Zwarenstein. Our review is written in the new Cochrane format and also has additional primary and secondary outcomes to the original review. Since the publication of the previous review, no new studies regarding the efficacy of chest radiographs in the treatment of acute LRTIs have been identified. We also thank the following people for commenting on the draft of this review: Anne Lyddiatt, Joan Moller, Craig Mellis, Nelcy Rodriguez and Inge Axelsson. We are most appreciative of Sarah Thorning for assisting with the searches for this review.

REFERENCES

References to studies included in this review

Bushyhead 1983 *{published data only}*
Bushyhead JB, Wood RW, Tompkins RK, Wolcott BW, Diehr P. The effect of chest radiographs on the management and clinical course of patients with acute cough. *Medical Care* 1983;**21**(7):661–73.

Swingler 1998 *{published data only}*
Swingler GH. Response to email request from Cao AMY. Email correspondence 2 March 2013.
* Swingler GH, Hussey GD, Zwarenstein M. Randomised controlled trial of clinical outcome after chest radiograph in ambulatory acute lower-respiratory infection in children. *Lancet* 1998;**351**:404–8.

References to studies excluded from this review

Bourayou 2011 *{published data only}*
Bourayou R, Zenkhri F, Pariente D, Kone-Paut I. What is the value of the chest radiography in making the diagnosis of children pneumonia in 2011?. *Archives of Pediatrics & Adolescent Medicine* 2011;**18**(11):1251–4. [DOI: 10.1016/j.arcped.2011.06.002.]

Briel 2006 *{published data only}*
Briel M, Young J, Tshudi P, Hersberger KE, Hugenschmidt C, Langewitz W, et al. Prevalence and influence of diagnostic tests for acute respiratory tract infections in primary care. *Swiss Medical Weekly* 2006;**136**:248–53.

Colucci 2012 *{published data only}*
Colucci N, McCormick A, Chan SB. Pediatric chest x-rays in the febrile emergency department patient. *Annals of Emergency Medicine* 2012;**60**(Suppl):100.

Lynch 2004 *{published data only}*
Lynch T, Gouin S, Larson C, Patenaude Y. Does the lateral chest radiograph help pediatric emergency physicians diagnose pneumonia? A randomised clinical trial. *Academic Emergency Medicine* 2004;**11**(6):625–9.

Ralston 2012 *{published data only}*
Ralston S, Garber M, Narang S, Shen M, Pate B, Pope J, et al. Decreasing unnecessary utilisation in acute bronchiolitis care: results from the value in inpatient pediatrics network. *Journal of Hospital Medicine* 2013;**8**(1):25–30.

Swingler 2000 *{published data only}*
Swingler GH. Chest radiography in ambulatory children with acute lower respiratory infections: effective tuberculosis case-finding?. *Annals of Tropical Paediatrics* 2000;**20**(1):11–5.

Additional references

ATS 2005
American Thoracic Society. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. American Journal of Respiratory and Critical Care Medicine 2005; Vol. 171: 388–416.

Basi 2004
Basi SK, Marrie TJ, Huang JQ, Majumdar SR. Patients admitted to hospital with suspected pneumonia and normal chest radiographs: epidemiology, microbiology, and outcomes. *American Journal of Medicine* 2004;**117**(5):305–11.

Bjerre 2009
Bjerre LM, Verheij TJM, Kochen MM. Antibiotics for community acquired pneumonia in adult outpatients. *Cochrane Database of Systematic Reviews* 2009, Issue 4. [DOI: 10.1002/14651858.CD002109.pub3]

Boiselle 1997
Boiselle PM, Tocino I, Hooley RJ, Pumerantz AS, Selwyn PA, Neklesa VP, et al. Chest radiograph interpretation of pneumocystis carinii pneumonia, bacterial pneumonia, and pulmonary tuberculosis in HIV-positive patients: accuracy, distinguishing features, and mimics. *Journal of Thoracic Imaging* 1997;**12**(1):47–53.

Chudi 2010
Chudi I. Healthcare problems in developing countries. *Medical Practice and Reviews* 2010;**1**(1):9–11.

Diederich 2000
Diederich S, Lenzen H. Radiation exposure associated with imaging of the chest. *Cancer* 2000;**89**(11):2457–60.

Gharib 1990
Gharib AM, Stern EJ. Radiology of pneumonia. *Medical Clinics of North America* 2001;**85**(5):1461–91.

Gould 2007
Gould MK, Fletcher J, Iannettoni MD, Lynch WR, Midthun DE, Naidich DP, et al. Evaluation of patients with pulmonary nodules: when is it lung cancer?: ACCP evidence-based clinical practice guidelines (2nd edition). *Chest* 2007;**132**(Suppl 3):108–30.

Higgins 2011
Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration. Available from www.cochrane-handbook.org 2011.

Hopstaken 2004
Hopstaken RM, Witbraad T, Van Engelshoven JMA, Dinant GJ. Inter-observer variation in the interpretation of chest radiographs for pneumonia in community acquired lower respiratory tract infections. *Clinical Radiology Journal* 2004;**59**(8):743–52.

Lefebvre 2011
Lefebvre C, Manheimer E, Glanville J. Chapter 6: Searching for studies. In: Higgins JPT, Green S editor(s). *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 (updated March 2011). The Cochrane Collaboration. Available from www.cochrane-handbook.org*. Chichester, UK: Wiley-Blackwell, 2011.

Lodha 2013
Lodha R, Kabra S, Pandey RM. Antibiotics for community-acquired pneumonia in children. *Cochrane Database of Systematic Reviews* 2013, Issue 6. [DOI: 10.1002/14651858.CD004874.pub4]

Lozano 2007
Lozano JM. Bronchiolitis in children. http://clinicalevidence.bmj.com/ (accessed 1 July 2010) 2007.

Mandell 2007
Mandell LA, Wunderink RG, Anzueto A, Bartlett JG, Campbell GD, Dean NC, et al. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. *Clinical Infectious Diseases* 2007;**44**(Suppl 2):27–72.

Mandell 2010
Mandell L. Community acquired pneumonia. *BMJ* 2010; **341**:c2916.

Maru 2010
Maru DS, Schwarz R, Andrews J, Basu S, Sharma A, Moore C. Turning a blind eye: the mobilisation of radiology services in resource-poor regions. *Global Health* 2010;**6**:18.

PAHO 2012
Pan American Health Organisation. World radiography day: two-thirds of the world's population has no access to diagnostic imaging. http://new.paho.org/hq/index.php?option=com˙content&view=article&id=7410:dia-de-la-radiografia-dos-tercios-de-la-poblacion-mundial-no-tiene-acceso-al-diagnostico-por-imagen&catid=740:news-press-releases&Itemid=1926&lang=en 2012 (Accessed on 24 December 2013).

Pleis 2008
Pleis JR, Lucas JW, Ward BW. Summary health statistics for U.S. adults: national health interview survey 2008. *http://www.cdc.gov/nchs/nhis.htm* 2009 (accessed 30 August 2010); **10**(242):1–157.

RevMan 2012 [Computer program]
The Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan). Version 5.2. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012.

Roqué i Figuls 2012
Roqué i Figuls M, Giné-Garriga M, Granados Rugeles C, Perrotta C. Chest physiotherapy for acute bronchiolitis in paediatric patients between 0 and 24 months old. *Cochrane Database of Systematic Reviews* 2012, Issue 2. [DOI: 10.1002/14651858.CD004873.pub4]

Ruiz 2000
Ruiz M, Arosio C, Salman P, Bauer TT, Torres A. Diagnosis of pneumonia and monitoring of infection eradication. *Drugs* 2000;**60**(6):1289–302.

Smith 2011
Smith SM, Fahey T, Smucny J, Becker LA. Antibiotics for acute bronchitis. *Cochrane Database of Systematic Reviews* 2011, Issue 11. [DOI: 10.1002/14651858.CD000245.pub2]

Spurling 2011
Spurling GKP, Doust J, Del Mar CB, Eriksson L. Antibiotics for bronchiolitis in children. *Cochrane Database of Systematic Reviews* 2011, Issue 6. [DOI: 10.1002/14651858.CD005189.pub3]

Trotter 2008
Trotter CL, Stuart JM, George R, Miller E. Increasing hospital admissions for pneumonia, England. *Emerging Infectious Diseases Journal* 2008;**14**(5):847–8.

Wark 2008
Wark P. Bronchitis (acute). Clinical Evidence (Accessed 23 September 2010).

WHO 2004
World Health Organization. The Global Burden of Disease: 2004 update. http://www.who.int/healthinfo/global˙burden˙disease/2004˙report˙update/en/index.html (Accessed 24 December 2013).

WHO 2011
World Health Organization. Disease and injury regional estimates. http://www.who.int/healthinfo/global˙burden˙disease/estimates˙regional/en/index.html (Accessed 2 August 2013).

WHO 2013
Chronic Obstructive Pulmonary Disease. Available from http://www.who.int/tobacco/research/copd/en/ (Accessed 24 December 2013).

WNA 2011
World Nuclear Association. Nuclear radiation and health effects. http://www.world-nuclear.org/info/Safety-and-

Security/Radiation-and-Health/Nuclear-Radiation-and-Health-Effects/#.UiE2-X-NAwM (Accessed 1 February 2013).

Woodhead 2005
Woodhead M, Blasi F, Ewig S, Huchon G, Leven M, Ortqvist A, et al. Guidelines for the management of adult lower respiratory tract infections. *European Respiratory Journal* 2005;**26**:1138–80.

Yang 2013
Yang M, Yan Y, Yin X, Wang BY, Wu T, Liu GJ, et al. Chest physiotherapy for pneumonia in adults. *Cochrane Database of Systematic Reviews* 2013, Issue 2. [DOI: 10.1002/14651858.CD006338.pub3]

References to other published versions of this review

Swingler 2008
Swingler GH, Zwarenstein M. Chest radiograph in acute respiratory infections. *Cochrane Database of Systematic Reviews* 2008, Issue 1. [DOI: 10.1002/14651858.CD001268.pub3]

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Bushyhead 1983

Methods	Randomised controlled trial (Phase III: February 1977 to February 1979) 3-phase study
Participants	The study was conducted with 2018 consecutive patients (1502 in Phase III) at emergency room and walk-in clinic of "Brooke Army Medical Center at Fort Sam Houston, Texas" "The 2018 patients in the three phases of this study were predominantly retired military personnel and military dependents; a minority were active-duty Army troops. Most Participants were Caucasian (79 per cent). There were more women than men; the patients' ages were distributed bimodally with peaks at 13 to 20 and 51 to 60 years, with a mean age of 38." **Inclusion criteria:** "Consenting, nonpregnant, adult patients seeking medical care for the first time for coughs of less than one month's duration" **Exclusion criteria**: pulse rate of 160 or more, temperature 104 °F (40 °C) or more, systolic blood pressure 90 mmHg or lower, patients arriving by stretcher
Interventions	"The independent variable in this randomised, controlled trial is the **availability to the physician of the chest film results**. Dependent variables are the physicians' management plans and the patient outcomes." **Phase I** - Chest radiographs were only taken on physicians' request and all requested radiographs were seen - Resembles normal physician practice - "The physicians did not try to predict chest radiograph findings and did not make assessments and plans before seeing the films" - N = 199 **Phase II** - Chest radiographs taken of all patients - Physicians saw chest radiographs only if they ordered them - Second physician reviewed chest radiographs and clinical records of patients whose films were not seen and intervened when plans were dangerously inappropriate - N = 288 **Phase III** - PA (Posterior to Anterior) and lateral chest radiographs taken of all patients - Determined by lot with 1:1 odds randomisation for whether physicians would receive the radiology report and chest radiograph - The physicians recorded their estimate of the most likely finding on the chest radiograph, the probability of this finding, the probability of an infiltrate on the chest radiograph and the probable microbiological cause of the illness - Physicians wrote down whether they wished to order a chest radiograph and why they wanted to. This had no bearing on whether physicians saw the radiographs - Physicians randomised to the intervention group were allowed to change diagnosis and management plans on the basis of radiology results

Bushyhead 1983 (*Continued*)

	- N = 1502 (chest radiographs provided in 739 patients, radiographs not provided in 763)
Outcomes	The effect of chest radiographs on the management and clinical course of patients with acute cough - "Effectiveness of pneumonia diagnosis and treatment" - "Effect of the chest film on physicians' plans" - "Effect of chest radiograph on illness outcome" - "Effect of study design on physicians' decisions"
Notes	"Evaluation of the usefulness of chest radiographs in the care of patients presenting for the first time with acute cough" "We assume that a test is valuable if its use results in effective changes in patient management plans or better patient outcomes." Only Phase III results were relevant to our review - hence only Phase III results were discussed

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	**Phase I** - "To ensure a study population comparable with that of Phase III, in Phase I we selected for participation only patients who verbally agreed to the Phase III protocol" **Phase III** - "We determined by lot, with 1:1 odds, whether or not the physician caring for the patient would receive the chest films and the radiologist's readings" It is not described how the random numbers or "lot" were generated
Allocation concealment (selection bias)	Low risk	"The physicians had to make their diagnostic, treatment, and follow-up decisions before patient randomisation but after the clinical evaluation of the patient. These plans could be revised only if the patient were randomised to the group whose chest films and radiologists' readings were made available, and then only after the physician reviewed this information." **Phase I** - "Chest films were taken only on physicians' requests, and the physicians saw all requested chest radiographs" - "This phase resembled ordinary physician practice" - Allocation concealment not applicable as

		this phase aims to model the day-to-day practice for a 'gold standard' **Phase II** - "We took chest radiographs of all patients. However, physicians saw the chest films only if they had ordered them." **Phase III** - "Without knowledge of chest film results. .. physicians reviewed and checked the history and performed a standard physical examination" - "We required clinicians to record diagnoses and management plans for all patients before they knew whether or not they would see the chest films...They noted whether they wished to order a chest radiograph for the patient and if so, why. These decisions had no bearing on whether the physicians saw the radiographs."
Blinding of outcome assessment (detection bias) All outcomes	High risk	"Primary outcome (time to recovery) assessed blind to treatment group. Assessment of secondary outcomes was not blinded." "Radiology residents, with staff radiologists available for consultation, read each chest radiograph. The only clinical information available to them was that the patient had an acute cough. When available, previous chest films were used in reading the films.. ." "Without knowledge of chest film results, research assistants collected a standard history from all patients."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Analysis was by intention-to-treat "However, when physicians felt that viewing the films was essential to the patients' health, the patients were excluded from randomisation, and physicians saw their chest films. This occurred with only 2 per cent of patients."
Selective reporting (reporting bias)	Low risk	No trial protocol was available. However, all outcomes were reported
Other bias	Unclear risk	"For ethical reasons, a physician not otherwise active in the study reviewed the medical records and chest films of all patients

Bushyhead 1983 (*Continued*)

		whose films were not given to their physicians. The reviewing physician did not intervene in the patient's care unless management plans seemed dangerously inappropriate." "As in Phase III, a second physician reviewed the radiographs and clinical records of all patients whose films were not seen by their clinicians, and intervened when plans were believed dangerously inappropriate." No conflicts of interest and financial disclosures reported

Swingler 1998

Methods	Randomised controlled trial (September 1995 to September 1996 "on weekday mornings")
Participants	581 patients enrolled. 522 allocated to radiograph or to the control group (59 excluded) **Inclusion criteria:** "Children aged 2 to 59 months who presented to the Red Cross Children's Hospital [Cape Town] as their first contact were eligible for this study if they met the WHO case definition for pneumonia (i.e. cough and tachypnoea but drinking well and without chest indrawing, cyanosis, abnormal level of consciousness or stridor)." "Tachypnoea was defined as a respiratory rate of 50 breaths or more/min in children aged 2 to 11 months, and 40 breaths or more/min in children aged 12 months or more. " **Exclusion criteria:** "cough of more than 14 days duration, history of current household contact with active tuberculosis, a localised wheeze, clinical signs of cardiac failure or the clinician's assessment that a chest radiograph was mandatory" "The study was done in the primary general outpatients section. Patients were enrolled from September, 1995, to September, 1996, on weekday mornings. An experienced registered nurse screened all waiting patients, and identified eligible individuals. Baseline information collected at this stage included age, weight, duration of symptoms before presentation, and respiratory rate." N = 522
Interventions	"Eligible patients identified by the nurse were seen by a clinician. After the medical history of each patient was taken and an examination done, eligible patients were allocated to the radiograph or to the control group." "The intervention was the use of a chest radiograph (anteroposterior and lateral views) . The chest radiograph was viewed by the clinician and a routine report supplied by the duty paediatric radiologist or radiology registrar was available with the films. The control was standard of care without a chest radiograph. All other management was entirely at the discretion of the clinician." - N = 286 allocated to have chest radiograph - 13 did not have it done - 273 children X-rayed

Swingler 1998 (*Continued*)

Outcomes	"The primary outcome measure was time to recovery, measured by twice weekly structured telephone interviews of the subset of 295 participants contactable by telephone." "Respondents were asked 'Is (child's name) completely well yet?' If the answer was 'Yes', the next questions was 'On what day was he/she last sick?'. Answers to three of the questions in the questionnaire (subsequent visits and admissions to the Children's Hospital and subsequent chest radiographs done there) were verified by examination of the clinical records" "Subsidiary outcomes were management options used (additional tests ordered, number of drugs per prescription, antibiotic use, follow-up appointment, and immediate admission to hospital) and other clinical outcomes (return visits and later hospital admission) . All subsidiary outcomes were ascertained by examination of clinical records of all patients by the principal investigator (whether contactable by telephone or not), except for visits to facilities other than the Children's Hospital, which were measured by the above telephone interview."
Notes	"The aim of this study was to quantify the effect of the use of chest radiographs on the management and clinical outcome in children with ambulatory acute lower respiratory tract infection, and to determine whether any such effect was dependent on the experience of the clinician"

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	"..the random allocation [was] generated in advance by the principal investigator (by tossing a coin)."
Allocation concealment (selection bias)	High risk	"Allocation was done by the clinician opening a sealed sequentially numbered manila envelope attached to the consultation sheet and containing the random allocation..." "If a patient was excluded by the clinician before randomisation the sealed envelope was returned to the principal investigator. The return of envelopes was audited." "There were no differences in baseline characteristics between groups or between randomised and excluded patients."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	"The telephone interviewer was not informed of the study hypothesis, was blind to the randomisation status of the patients, and had no contact with the hospital other than through the principal investigator. On casual enquiry at the end of the study, the interviewer had guessed only that the study dealt with chest infections."

		"Coding and cleaning of telephone questionnaire data was done without knowledge of treatment group by the principal investigator on a separate data capture sheet and in a separate database."
Incomplete outcome data (attrition bias) All outcomes	High risk	"Patients were analyzed by intention-to-treat" "Of the 581 eligible patients identified by the registered nurse, 59 (26 contactable by telephone) were excluded by the clinicians before randomisation. The remaining 522 patients were randomly allocated, 259 to the radiograph group and 263 to the control group. Four (1.5%) patients in the radiograph group did not receive the intervention whereas 7 (2.7%) of the control group had a radiograph on the day of randomisation" "295 (77.5%) of the patients providing a telephone number were followed till recovery or censored at 28 days. Of the 522 participants 518 (99.2%) record sheets of the first consultation were retrieved, and all 522 folders for assessment of subsequent visits. " "Although 22% of participants who had a telephone number were lost to follow-up: loss was similar between treatment groups. In addition, the lack of effect of a chest radiograph measured by telephone interview is consistent with the lack of effect on outcomes measured by examination of clinical records, where follow-up was virtually complete."
Selective reporting (reporting bias)	Low risk	No trial protocol was available. However, all outcomes were reported
Other bias	Unclear risk	"Reliability of record review was assessed by repeat examination of a 10% random sample of clinical records by a second observer not involved in the study. 12 items were assessed: exclusion before randomisation, treatment allocation, clinician's perceived need for chest radiograph, diagnosis, and the outcome variable listed..." No conflicts of interest and financial disclosures reported. However, "this study was

Swingler 1998 (*Continued*)

		supported by the Medical Research Council of South Africa and the University of Cape Town." Note: potential recruitment bias as "Patients were enrolled from September 1995 to September 1996 *on weekday mornings*."

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Bourayou 2011	Not a randomised controlled trial. "We have attempted to clarify [chest radiographs'] diagnostic value in community acquired pneumonia in children through a **literature review**..."
Briel 2006	Study outcomes not relevant to our review outcomes: "**Prevalence** of diagnostic tests" "Association between patient characteristics and use of tests" "Association between test results and diagnosis and treatment" "Association between test use and patient satisfaction and enablement" "GPs relied on test results when making decisions about diagnosis & antibiotic treatment". However, study does not distinguish between chest radiographs and other blood tests
Colucci 2012	"One year **retrospective** study of children...at 2 community hospitals..." "To determine if the disposition and therapeutic interventions for the children directly correlate to the radiography"
Lynch 2004	Outcomes not relevant to our review outcomes. "The primary outcome variable was the difference in the sensitivity and specificity of the emergency **physicians' interpretations** of chest radiographs with access to two views (frontal and lateral) versus one view (frontal for children with suspected pneumonia." "A secondary outcome included the **change in management** provided by the review of the two views by the radiologist."
Ralston 2012	Not a randomised controlled trial. "Our objective was to reduce utilization of unnecessary therapies in the inpatient care of bronchiolitis across a diverse network of clinical sites" "We formed a voluntary **quality improvement** collaborative of paediatric hospitals for the purpose of benchmarking the use of bronchodilators, steroids, chest radiography, chest physiotherapy, and viral testing in bronchiolitis using hospital administrative data. We shared resources within the network, including protocols, scores, order sets, and key bibliographies, and established group norms for decreasing utilization."
Swingler 2000	Not a randomised controlled trial. Appears to be a selected **case review** of tuberculosis of a previously published study (Swingler 1998). Swingler 1998 is already included in our review

DATA AND ANALYSES

Comparison 1. Chest radiograph versus management without chest radiograph (children only)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Time to resolution of clinical signs and symptoms	1	518	Mean Difference (IV, Fixed, 95% CI)	0.0 [-1.81, 1.81]
2 Hospitalisation rates	1	518	Risk Ratio (M-H, Fixed, 95% CI)	2.03 [0.77, 5.33]

Analysis 1.1. Comparison 1 Chest radiograph versus management without chest radiograph (children only), Outcome 1 Time to resolution of clinical signs and symptoms.

Review: Chest radiographs for acute lower respiratory tract infections

Comparison: 1 Chest radiograph versus management without chest radiograph (children only)

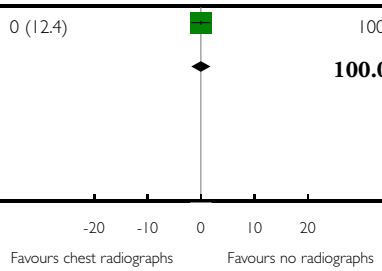
Outcome: 1 Time to resolution of clinical signs and symptoms

Study or subgroup	Chest radiographs N	Mean(SD)	No chest radiographs N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Swingler 1998	257	0 (8.2)	261	0 (12.4)		100.0 %	0.0 [-1.81, 1.81]
Total (95% CI)	**257**		**261**			**100.0 %**	**0.0 [-1.81, 1.81]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P = 1.0)

Test for subgroup differences: Not applicable

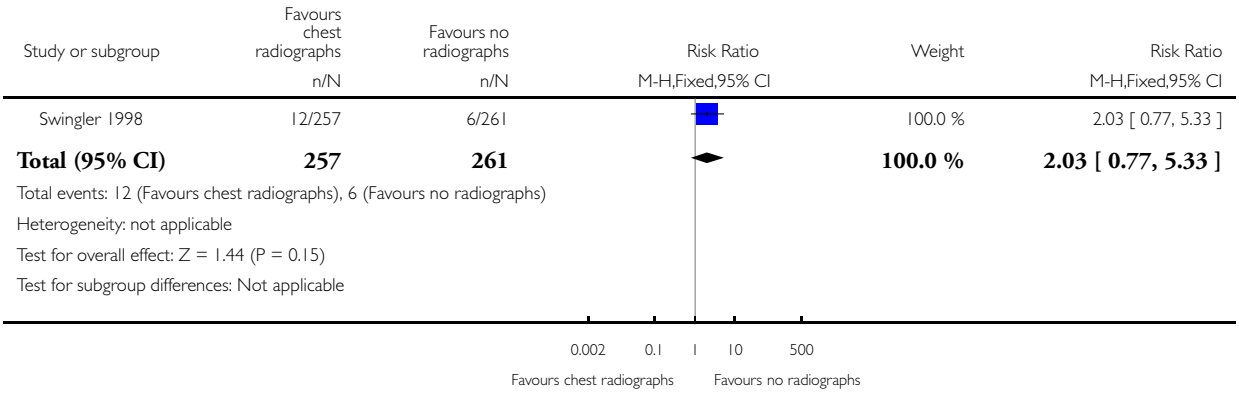


Analysis 1.2. Comparison 1 Chest radiograph versus management without chest radiograph (children only), Outcome 2 Hospitalisation rates.

Review: Chest radiographs for acute lower respiratory tract infections

Comparison: 1 Chest radiograph versus management without chest radiograph (children only)

Outcome: 2 Hospitalisation rates



ADDITIONAL TABLES

Table 1. Time to resolution of clinical signs and symptoms (children only)

Study	Chest radiograph			Without chest radiograph		
	Median (days)	SD	Total	Median (days)	SD	Total
Swingler 1998	7	8.2	257	7	12.4	261

Chest radiograph versus management without chest radiograph (children only), outcome: 1.1 Time to resolution of clinical signs and symptoms.

APPENDICES

Appendix 1. MEDLINE (Ovid) search strategy

1 exp Radiography, Thoracic/
2 ((chest or lung* or thora*) adj3 (radiograph* or radiogram* or radiology or roentgen* or x-ray* or x ray* or xray*)).tw.
3 1 or 2
4 exp Respiratory Tract Infections/
5 acute respiratory infection*.tw.
6 lower respiratory infection*.tw.
7 lower respiratory tract infection*.tw.
8 exp Pneumonia/
9 (pneumon* or bronchopneumon* or pleuropneumon*).tw.
10 exp Bronchitis/
11 (bronchit* or bronchiolit*).tw.
12 exp Empyema/
13 empyema.tw.
14 Cough/
15 cough*.tw.
16 wheez*.tw.
17 Hemoptysis/
18 (hemoptysis or haemoptysis).tw.
19 Sputum/
20 sputum.tw.
21 fever/ or "fever of unknown origin"/
22 (fever* or pyrexia).tw.
23 exp Pleurisy/
24 (pleurisy or pleuritis).tw.
25 Pleural Effusion/
26 exp Dyspnea/
27 (dyspnoea or dyspnea).tw.
28 Respiratory Sounds/
29 (rales or crackles or rhonchi).tw.
30 Lung abscess/
31 (lung abscess* or pulmonary abscess*).tw.
32 or/4-31
33 3 and 32

Appendix 2. Embase.com search strategy

#38. #34 AND #37
#37. #35 OR #36
#36. random*:ab,ti OR placebo*:ab,ti OR factorial*:ab,ti OR crossover*:ab,ti OR 'cross over':ab,ti OR 'cross-over':ab,ti OR volunteer*:ab,ti OR allocat*:ab,ti OR assign*:ab,ti OR ((singl* OR doubl*) NEAR/1 blind*):ab,ti
#35. 'randomized controlled trial'/exp OR 'single blind procedure'/exp OR 'double blind procedure'/exp OR 'crossover procedure'/exp
#34. #4 AND #33
#33. #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26
OR #27 OR #28 OR #29 OR #30 OR #31 OR #32
#32. 'lung abscess':ab,ti OR 'pulmonary abscess':ab,ti
#31. 'lung abscess'/de
#30. rales:ab,ti OR crackles:ab,ti OR rhonchi:ab,ti
#29. 'abnormal respiratory sound'/de

#28. dyspnea:ab,ti OR dyspnoea:ab,ti
#27. 'dyspnea'/exp
#26. 'pleura effusion'/de
#25. pleurisy:ab,ti OR pleuritis:ab,ti
#24. 'pleurisy'/exp
#23. fever*:ab,ti OR pyrexia:ab,ti
#22. 'pyrexia idiopathica'/de
#21. 'fever'/de
#20. sputum:ab,ti
#19. 'sputum'/de AND [embase]/lim
#18. hemoptysis:ab,ti OR haemoptysis:ab,ti
#17. 'hemoptysis'/de
#16. wheez*:ab,ti
#15. 'wheezing'/de
#14. cough*:ab,ti
#13. 'coughing'/exp
#12. empyema:ab,ti
#11. 'empyema'/exp
#10. bronchit*:ab,ti OR bronchiolit*:ab,ti
#9. 'bronchitis'/exp
#8. pneumon*:ab,ti OR bronchopneumon*:ab,ti OR pleuropneumon*:ab,ti
#7. 'pneumonia'/exp
#6. 'acute respiratory infection':ab,ti OR 'acute respiratory infections':ab,ti OR 'lower respiratory infection':ab,ti OR 'lower respiratory infectons':ab,ti OR 'lower respiratory tract infection':ab,ti OR 'lower respiratory tract infections':ab,ti
#5. 'lower respiratory tract infection'/exp
#4. #1 OR #2 OR #3
#3. 'chest xray':ab,ti OR 'chest x-ray':ab,ti OR 'lung xray':ab,ti OR 'lung x-ray':ab,ti OR 'lung x ray':ab,ti OR 'thoracic xray':ab,ti OR 'thorax xray':ab,ti OR 'thoracic x-ray':ab,ti OR 'thorax x-ray':ab,ti OR 'thoracic x ray':ab,ti OR 'thorax x ray':ab,ti
#2. ((chest OR lung* OR thora*) NEAR/3 (radiograph* OR radiogram* OR radiology OR roentgen*)):ab,ti
#1. 'thorax radiography'/exp

Appendix 3. CINAHL (Ebsco) search strategy

S52 S42 and S51
S51 S43 or S44 or S45 or S46 or S47 or S48 or S49 or S50
S50 (MH "Quantitative Studies")
S49 TI placebo* or AB placebo*
S48 (MH "Placebos")
S47 TI random* or AB random*
S46 TI (singl* blind* or doubl* blind* or tripl* blind* or trebl* blind* or singl* mask* or doubl* mask* or tripl* mask* or trebl* mask*) or AB (singl* blind* or doubl* blind* or tripl* blind* or trebl* blind* or singl*mask* or doubl* mask* or tripl* mask* or trebl* mask*)
S45 TI clinic* trial* or AB clinic* trial*
S44 PT clinical trial
S43 (MH "Clinical Trials+")
S42 S14 and S41
S41 S15 or S16 or S17 or S18 or S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30 or S31 or S32 or S33 or S34 or S35 or S36 or S37 or S38 or S39 or S40
S40 TI (lung abscess* or pulmonary abscess*) or AB (lung abscess* or pulmonary abscess*)
S39 (MH "Lung Abscess")
S38 TI (rales or crackles or rhonchi) or AB (rales or crackles or rhonchi)
S37 (MH "Respiratory Sounds")
S36 TI (dyspnea or dyspnoea) or AB (dyspnea or dyspnoea)

S35 (MH "Dyspnea+")
S34 (MH "Pleural Effusion")
S33 TI (pleurisy or pleuritis) or AB (pleurisy or pleuritis)
S32 (MH "Pleurisy")
S31 TI (fever* or pyrexia) or AB (fever or pyrexia)
S30 (MH "Fever") OR (MH "Fever of Unknown Origin")
S29 TI sputum or AB sputum
S28 (MH "Sputum")
S27 TI (hemoptysis or haemoptysis) or AB (hemoptysis or haemoptysis)
S26 (MH "Hemoptysis")
S25 TI wheez* or AB wheez*
S24 TI cough* or AB cough*
S23 (MH "Cough")
S22 TI empyema or AB empyema
S21 (MH "Empyema")
S20 (bronchit* or bronchiolit*) or (bronchit* or bronchiolit*)
S19 (MH "Bronchitis+")
S18 TI (pneumon* or bronchopneumon* or pleuropneumon*) or AB (pneumon* or bronchopneumon* or pleuropneumon*)
S17 (MH "Pneumonia+")
S16 TI (acute respiratory infection* or lower respiratory infection* or lower respiratory tract infection*) or AB (acute respiratory infection* or lower respiratory infection* or lower respiratory tract infection*)
S15 (MH "Respiratory Tract Infections+")
S14 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13
S13 TI thora* N3 roentgeno* or AB thora* N3 roentgeno*
S12 TI lung* N3 roentgeno* or AB lung* N3 roentgeno*
S11 TI chest N3 roentgeno* or AB chest N3 roentgeno*
S10 TI thora* N3 radiology* or AB thora* N3 radiology*
S9 TI lung* N3 radiology* or AB lung* N3 radiology*
S8 TI chest* N3 radiology* or AB chest* N3 radiology*
S7 TI thora* N3 radiogra* or AB thora* N3 radiogra*
S6 TI lung* N3 radiogra* or AB lung* N3 radiogra*
S5 TI chest* N3 radiogra* or AB chest* N3 radiogra*
S4 TI thora* N3 x#ray* or AB thora* N3 x#ray*
S3 TI lung* N3 x#ray* or AB lung* N3 x#ray*
S2 TI chest N3 x#ray* or AB chest N3 x#ray*
S1 (MH "Radiography, Thoracic+")

Appendix 4. LILACS search strategy

(mh:"Radiography, Thoracic" OR mh:e01.370.350.700.730$ OR "Radiografía Torácica" OR "chest radiograph" OR "Radiografías Pulmonares" OR "Radiografia Pulmonar" OR "chest xray" OR "chest x-ray" OR "chest x ray" OR "Radiografia de tórax" OR "Rayos x de tórax" OR "Radiografia del pulmon" OR "chest radiology" OR "chest radiogram") AND (mh:"Respiratory Tract Infections" OR mh:c01.539.739$ OR mh:c08.730$ OR "Infecciones del Sistema Respiratorio" OR "Infecções Respiratórias" OR "Infecciones de las Vías Respiratorias" OR "Infecciones del Aparato Respiratorio" OR "Infecciones del Tracto Respiratorio" OR "Infecciones Respiratorias" OR "Infecções das Vias Respiratórias" OR "Infecções do Aparelho Respiratório" OR "Infecções do Sistema Respiratório" OR "Infecções do Trato Respiratório" OR "acute respiratory infection" OR "acute respiratory infections" OR "lower respiratory infection" OR "lower respiratory infections" OR "lower respiratory tract infection" OR "lower respiratory tract infection" OR mh:pneumonia OR mh:c08.381.677$ OR mh:c08.730.610$ OR neumonía OR pneumonia OR "Inflamación Experimental del Pulmón" OR "Inflamación del Pulmón" OR "Neumonía Lobar" OR neumonitis OR "Inflamación Pulmonar" OR pneumonía OR pulmonía OR "Inflamação Experimental dos Pulmões" OR "Inflamação do Pulmão" OR "Pneumonia Lobar" OR pneumonite OR "Inflamação Pulmonar" OR pulmonia OR mh:bronchopneumonia OR bronconeumonía OR broncopneumonia OR bronchopneumon$ OR mh:pleuropneumonia OR pleuroneumonía OR pleuropneumonia OR pleuropneumon$ OR mh:bronchitis OR bronchit$ OR bronquitis OR bronquite OR

mh:c08.127.446$ OR mh:c08.381.495.146$ OR mh:c08.730.099$ OR bronchiolit$ OR bronquiolitis OR bronquiolite OR mh:empyema OR mh:c01.539.830.305$ OR empyema OR empiema OR mh:cough OR cough$ OR tos$ OR wheez$ OR "Ruidos de la Respiración" OR "Sonidos de la Respiración" OR "Ruidos Pulmonares" OR "Ruidos del Pulmón" OR "Roce Pleural" OR estertores OR ronquidos OR roncus OR sibilancias OR sibilancia OR crepitación OR "Sonidos Respiratorios" OR "Ruídos Respiratórios" OR "Sons da Respiração" OR "Ruídos da Respiração" OR "Ruídos Traqueobrônquicos" OR "Ruídos Traqueo-Brônquicos" OR "Sons Pulmonares" OR "Atrito Pleural" OR estertores OR roncos OR crepitação OR "Estertor Crepitante" OR mh:"Respiratory Sounds" OR rales OR crackles OR rhonchi OR mh:hemoptysis OR hemopt$ OR mh:sputum OR sputum OR esputo OR escarro OR mh:fever OR fever OR fiebre OR febre OR pyrexia OR mh:"Fever of Unknown Origin" OR "Fiebre de Origen Desconocido" OR "Febre de Causa Desconhecida" OR mh:pleurisy OR pleurisy OR pleuresia OR mh:"Pleural Effusion" OR "pleural effusion" OR "Derrame Pleural" OR mh:dyspnea OR dyspnea OR dyspnoea OR disnea OR dispnéia OR mh:"Lung Abscess" OR "lung abscess" OR "Absceso Pulmonar" OR "Abscesso Pulmonar")

Appendix 5. ClinicalTrials.gov search strategy

Interventional studies
Condition: lower respiratory tract infections OR pneumonia OR bronchitis OR empyema OR cough OR wheeze OR wheezing OR pleurisy
Intervention: radiograph OR radiography OR x-ray OR radiology OR roentgenogram

Appendix 6. WHO ICTRP search strategy

Pneumonia AND chest x-ray
(Bronchitis
Wheez*
Empyema
Cough*
Respiratory infection)

Pneumonia AND chest radiograph
(Bronchitis
Wheez*
Empyema
Cough*
Respiratory infection)

CONTRIBUTIONS OF AUTHORS

MvD and RB reviewed and provided expert advice regarding the content and the writing of the protocol and review. AC, JC and LM drafted and reviewed the protocol. AC and JC independently assessed and selected trials for inclusion with input from LM and MvD. AC, JC and LM drafted and edited the review. MvD edited, reviewed and provided guidance throughout the writing of this review. All review authors approved the final version.

DECLARATIONS OF INTEREST

At the time of publication of the protocol, Dr Roger Bain worked for IMed/GCMI - a private radiology provider at Tweed Hospital in Australia and at some private clinics. However, this is no longer the case and no potential declarable interests were identified at the time of writing this review.

The other review authors, AC, JC, LM and MvD, do not have any interests to declare.

SOURCES OF SUPPORT

Internal sources

- Bond University, Australia.

Primary Health Care Research and Evaluation Program (PHCRED)

External sources

- Funding, Not specified.

No funding received.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The reference to 'magnetic resonance imaging (MRI)' was removed from the Description of the intervention as they are rarely, if ever, used in the management of LRTIs. The use of the word 'X-ray' was changed to 'radiograph' throughout the review apart from the 'Plain language summary'.

INDEX TERMS

Medical Subject Headings (MeSH)

*Radiography, Thoracic; Acute Disease; Hospitalization [statistics & numerical data]; Randomized Controlled Trials as Topic; Respiratory Tract Infections [*diagnostic imaging]

MeSH check words

Adult; Child; Humans